A New Electronic Control System for Unmanned Underwater Vehicles.

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Abstract- *In this paper a new electronic control system for unmanned underwater vehicles is presented. This control system is characterized by a distribution in control over two network of type CANBus and Ethernet. This new electronic control system integrates functionalities of AUVs, as the automatic execution of preprogrammed trajectories. The control system also integrates an acoustic positioning system based on USBL. The information of relative positioning is sent through specific software tools towards NEPTUS Software for the command and control console of the unmanned vehicle, in this way it is possible to observe the positioning of the vehicle under water.*

Keywords- *UUV, electronic controllers, CANBUS, acoustics, usbl.*

1. INTRODUCTION

In recent years the price of components used in robotics has been greatly reduced, making these electronic technologies more accessible for building your own underwater robot. In this paper a new electronic control system that implements the basic functionality of the UUV vehicles using generic electronic components is presented. This new electronic control system is the base for building a new family of underwater vehicles at the Underwater Vehicles Laboratory of the Universidad Politécnica de Cartagena.

Fig 1. The AEGIR UUV in vehicle testing pool.

2. THE ELECTRONIC CONTROL SYSTEM.

In this paper a new electronic control system for unmanned underwater vehicles is presented. This control system is characterized by being distributed over two communication networks: CAN bus and Ethernet. On the CAN bus network output and input devices such as pressure sensors, motors, internal measures voltage and current, inclinometers and depth gauges are connected.

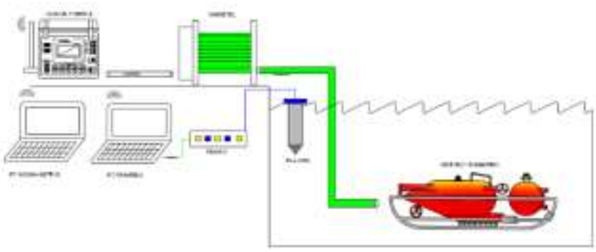

Fig 2. Electronic Control System of the AEGIR UUV.

The UUV consists of the following elements: underwater vehicle, winch, case control and acoustic positioning system and a vision system [1][2]. With these systems, the vehicle can be guided automatically, semi-automatic and manual to the targets. Throughout the underwater maneuver, the vehicle is sending real-time information about the image sonar, sidescan, and vision. The position of the vehicle is followed at all times by an acoustic positioning system, which represents the information system for monitoring underwater vehicles Neptus.

The CAN bus network

In the CAN bus network a high layer protocol is used, CANopen. By using CANopen protocol, the control of all CAN network has been developed using standard profiles for generic I/O modules (DS401) and drives and motion control (DSP-402), according to Can in Automation (CiA) recommendations.

All devices in the CANopen network are distributed through the head and body of the vehicle as shown below:

The CANopen network consists of three nodes distributed through the head and body of the vehicle. The function of each node has been designed according to its functionality and the physical place it takes in the vehicle.

Fig 3. The UUV (left). *CANopen network distribution.*

The node 1 is housed in the head of the vehicle and it handles the control of lights, head movement, camera power, and the adquisition of altitude, leak signal (head), pitch, roll, moisture and temperature inside the head. Node 2 and 3 are housed in the body. Node 2 is the controller of ventilation, leak signal (body), powering and handle of sonar sensors. The main functions of node 3 are the control and energy management of the engines.

All nodes are managed from the master of the CANopen network, the core of the control system of the AEGIR UUV vehicle. This master node is based on the SBRIO technology. This master node is the bridge between the Ethernet Network and the CAN Bus Network. This node implements the control modes: automatic, semiautomatic and manual, and also the alarm signals of the vehicle. If some emergency is detected, the vehicle initiates a security maneuver. The client nodes receive commands from the master and serve information about the state of its sensors. The client integrates a security mode based on watchdogs, if the clients do not receive a dataframe in a timeline, the client puts in security position to all its actuators.

Fig 4. CAN Electronic Controllers.

The Ethernet network

On the Ethernet network optical cameras, sidescan sonar, imaging sonar and the CPU of the vehicle are connected. The umbilical cord is part of the same Ethernet network and integrates surface monitoring equipment with on-board equipment.

Figure 3 shows the Ethernet network in the vehicle. The Ethernet network goes in the vehicle through the umbilical cord and connects to an Ethernet relay. This device is a switch to turn on the underwater vehicle by Ethernet Modbus commands. The Ethernet network is distributed to various elements connected to the controller body including an internal WIFI wireless access point to the vehicle. This WIFI access permits a quick verification with the vehicle out of water and without connection with the umbilical cable, which in some cases is very useful. From the body controllers the network is extended to the head controller via an umbilical cable connecting the two bodies. In the head, the camera optical vision, sidescan sonar and imaging sonar are connected to the Ethernet network.

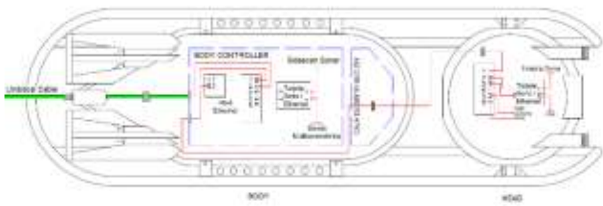

Fig 5. Ethernet Network.

For reduce the energy consumption, the vision camera, sidescan sonar and DVL are connected and disconnected for the CAN nodes.

The vehicle has the capability of integrating two cameras, in the figure 5 and image captured by the one of the camera is shown. The vision system is very versatile, because the camera can be changed easily.

Fig 4. Image from AEGIR Vision system.

The vehicle incorporate a imaging sonar for navigation. This device is connected to the vehicle through standard Ethernet converters, which allow using the manufacturer's own software.

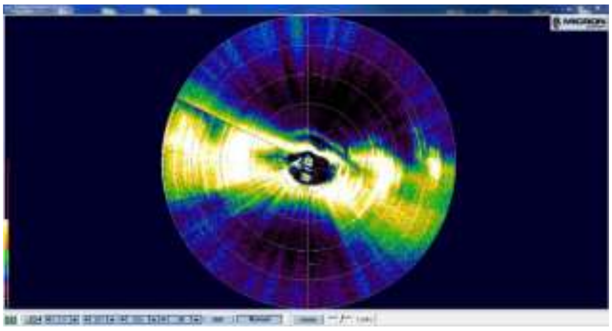

Fig 5. Imaging sonar Information.

The vehicle is ready to integrate a sound subbottom. In Figure 6, the subbotom images captured in preliminary testing of the subbotom sonar are shown.

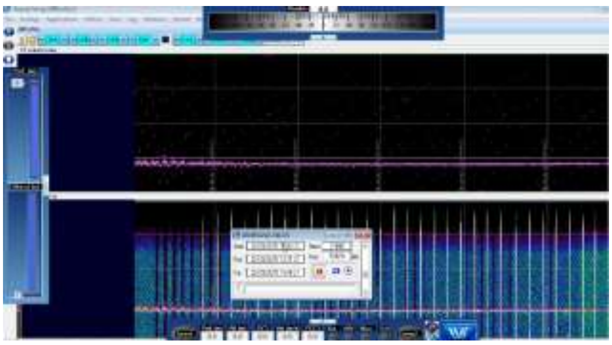

Fig 6. Subbottom Sonar.

Acoustic Positioning System

Positioning the underwater vehicle it is performed by the USBL system (*Ultra Short BaseLine*). For this a transducer and a transponder is used aboard the UUV.

We have developed a software tool that allows positioning the vehicle as a whole, based on the relative coordinates obtained with the USBL. For this purpose, it has a surface GPS, near the USBL. The software reads the global GPS coordinates and relative coordinates on the USBL, performs a merge and sends corresponding to the vehicle position, to NEPTUS [3] software the resulting coordinates.

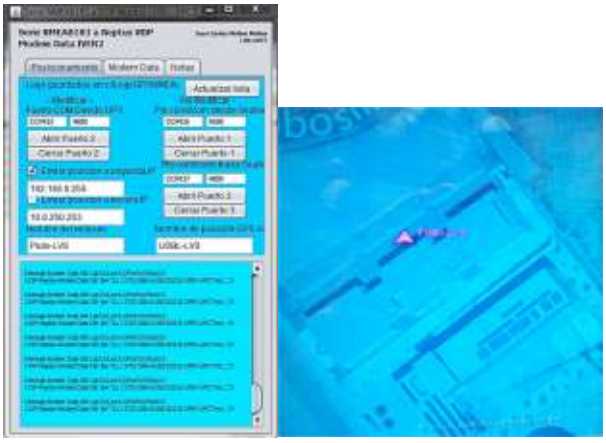

Fig 7. Fusión de coordenadas GPS y relativa. Envío del resultado a Neptus

3. SEA TRIALS AND VALIDATION.

The electronic control system has been tested in various scenarios, in a water pool at LVS installations, in controlled trials in the artificial lagoon in the Technological Park of Fuente Alamo, at the Mar Menor lagoon and at the bay of Cartagena.

In every operating test, the vehicle is tested in its 3 operating modes: manual, semiautomatic and automatic. In each maneuver, the performed of the overall perception devices system was tested. The vision system, sidescan sonar and imaging sonar is verified in each test.

The sequence of test are the following: first the vehicle is tested in the water pool at LVS installations, after a test of navitagion is done in the artificial Lagoon of Fuente Alamo and finally, the vehicle is ready for testing in open sea.

Figure 8 shows an experiment in the artificial lagoon in Fuente Alamo, in this photo the vehicle is performed a navigation test.

Fig.8. Test in Technology Park of Fuente Alamo.

Figure 9 shows an experiment in Cartagena bay. In these experiments all the capabilities of the vehicle was tested.

Fig.8. Test in Cartagena bay.

REFERENCES

[1] Garcia-Cordova, F., Guerrero-González, A., " Intelligent Navigation for a Solar Powered Unmanned Underwater Vehicle", International Journal of Advanced Robotic Systems", ISSN 1729-8806, Published: April 2, 2013, DOI: 10.5772/56029.

[2] Francisco Ortiz, Antonio Guerrero, Francisco Sánchez-ledesma, Francisco García-Cordova, Diego Alonso, Javier Gilabert, " Diseño del software de control de un UUV para monitorización oceanográfica usando un modelo de componentes y framework con despliegue flexible", Revista Iberoamericana de Automática e Informática Industrial 12 (2015) 325-337.

[3] Paulo Sousa Dias, GM Goncalves, RMF Gomes, JB Sousa, J Pinto, F Lobo Pereira, Mission planning and specification in the Neptus framework, Robotics and Automation, 2006. ICRA 2006. (Orlando). Proceedings IEEE International Conference, 15-19 May 2006, 10.1109/ROBOT.2006.1642192.